



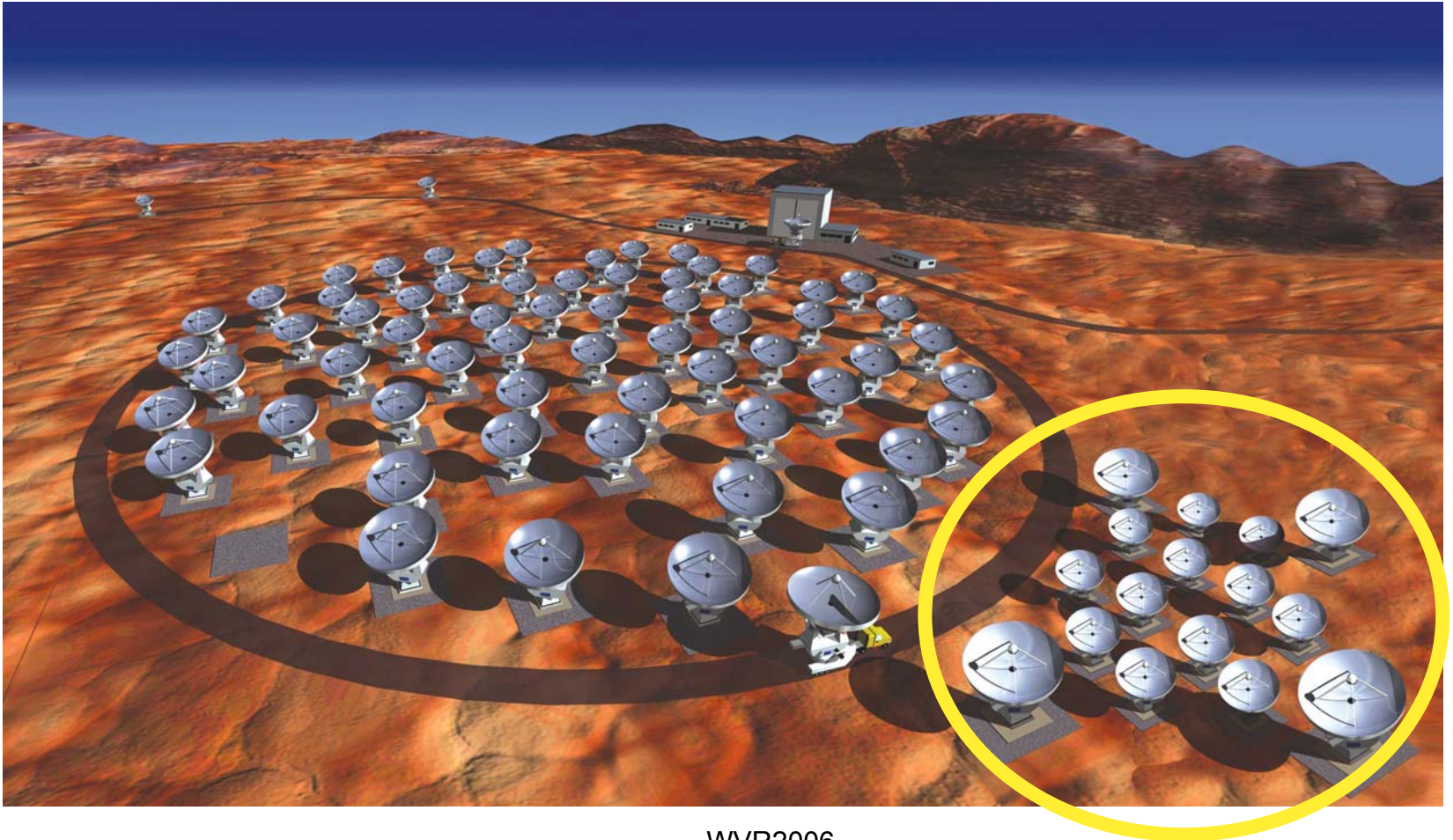
Phase Calibration with WVRs for the ACA

2006 October 10

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National Astronomical Observatory of Japan
National Institutes of Natural Sciences

Atacama Compact Array (ACA)



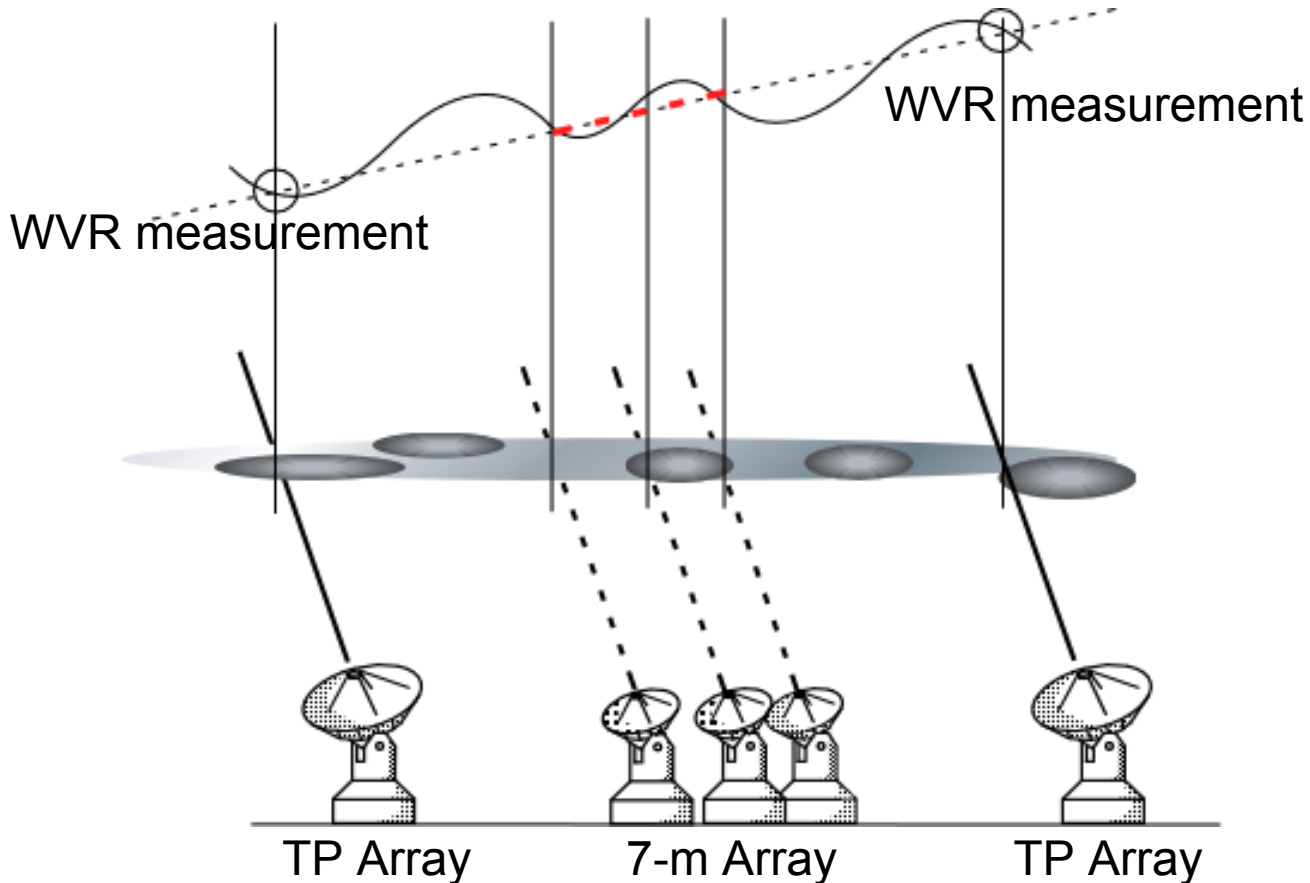


Phase-Correction for the ACA

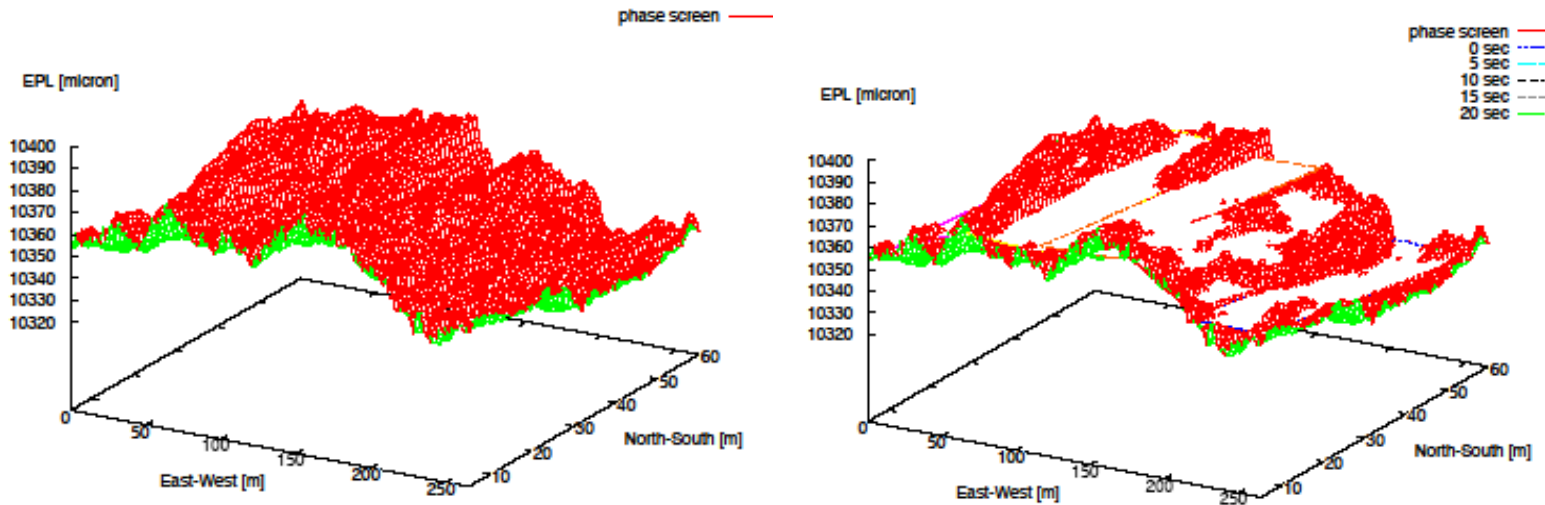
WVRs are attached to the TP Array to measure the atmospheric water vapor content.

- EPL due to the water vapor is fitted to a simple two-dimensional (2-D) slope using WVR measurements. Phase fluctuations of the 7-m Array are corrected using the 2-D slope.
- Decorrelation due to the atmospheric fluctuations can be evaluated from the WVR measurements.

Schematic Drawing of the Proposed Scheme

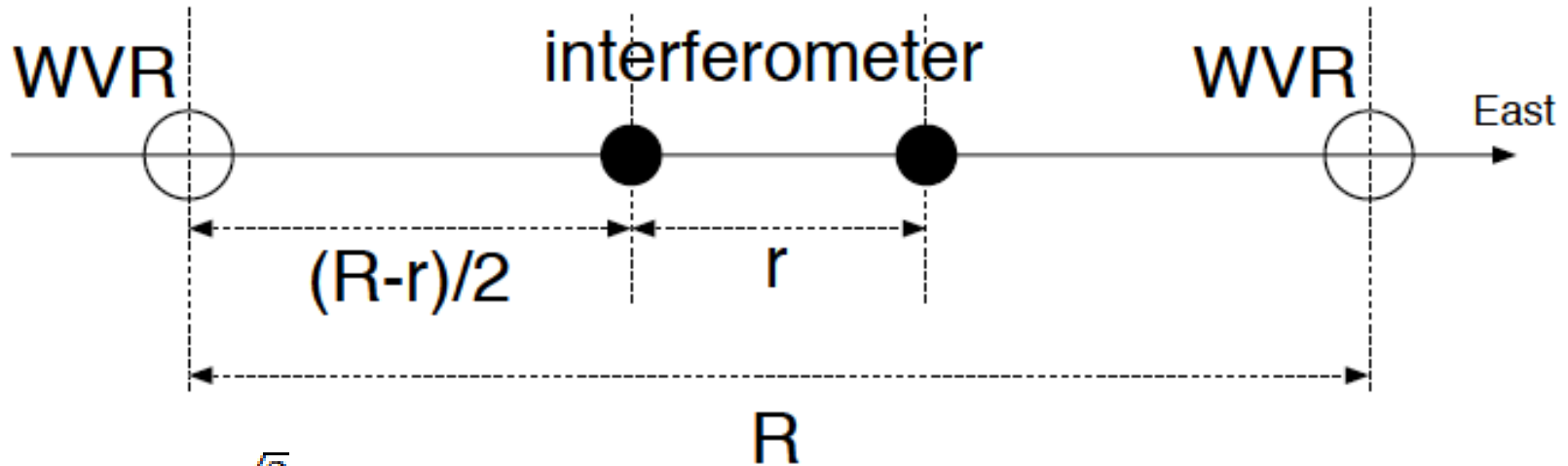


Example of the 2-D Screen Fitting



50-m sampling (1-s averaging)

Simple Statistical Model

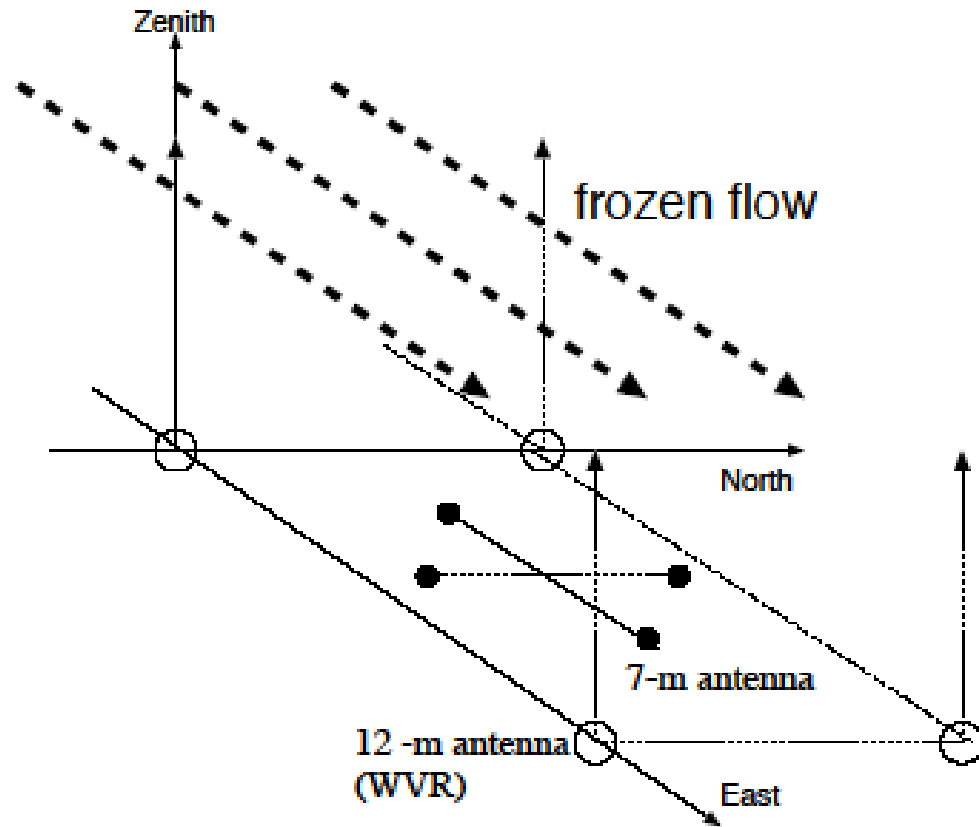


$$\sigma_{\text{fit}} = \frac{\sqrt{2}r}{R} \sigma_{\text{WVR}},$$

$$\sigma_{\text{trp}}^2 = D(r) + \left(\frac{r}{R}\right)^2 D(R) + \frac{2r}{R} \left\{ D\left(\frac{|R-r|}{2}\right) - D\left(\frac{R+r}{2}\right) \right\},$$

$$\sigma_{\text{total}} = \sqrt{\sigma_{\text{fit}}^2 + \sigma_{\text{trp}}^2} .$$

Simulations





Data Accumulation in the Simulations (1)

- Interferometer
 - Average the EPL phase screen spatially within the 7-m diameter cylindrical beam projected on the screen in every 0.1 sec.
 - Compute the differences of the averaged data between the 7-m antennas.
 - Average 10 consecutive differences per baseline to make 1-s averaged interferometer EPL difference.



Data Accumulation in the Simulations (2)

- WVR
 - Average the grid data of the EPL phase screen within the 12-m diameter cylindrical beam projected on the screen in every 0.1 sec.
 - Average 10 data to make 1-s averaged sample.
 - Add random Gaussian noise to the obtained samples.



Phase Calibration Adopted in the Simulations

- Carry out EPL 2-D slope fitting every one second with the WVR measurements.
- Infer the line-of-sight EPLs of the 7-m antennas from the slope.
- Estimate the interferometer EPL fluctuations for each baseline from the differences of the inferred line-of-sight EPLs for each pair of antennas.
- Calibrate the interferometer EPLs by subtracting the estimated EPL fluctuations.



Parameters Used in the Simulations

Grid interval of the screen	1 m
Screen height	1 km
Wind direction	West to East
Wind velocity (v)	5, 10 m/s
<PWV>	1.5 ^(*1) mm
Power law of SSF (α)	1.16 ^(*2) , 1.67 ^(*3)
Turbulent power of a 100-m baseline (RMS)	25, 50 ^(*4) , 100 ^(*5) μm
WVR measurement error	None, 7 ^(*6) , 25 ^(*7) μm

^(*1) Median value at Atacama site

^(*2) Holdaway (ALMA memo #490)

^(*3) Kolmogorov turbulence

^(*4) 25-percentile atmospheric condition (PWV=1.5 mm, α =1.16)

^(*5) 50-percentile atmospheric condition (PWV=1.5 mm, α =1.16)

^(*6) Hills (ALMA memo #495)

^(*7) ALMA WVR specification $/ * 10 (1 + \langle \text{PWV} \rangle) [\mu\text{m}] *$



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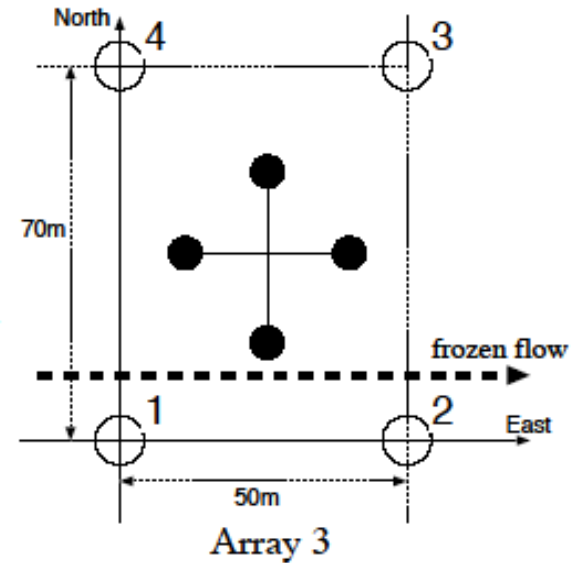
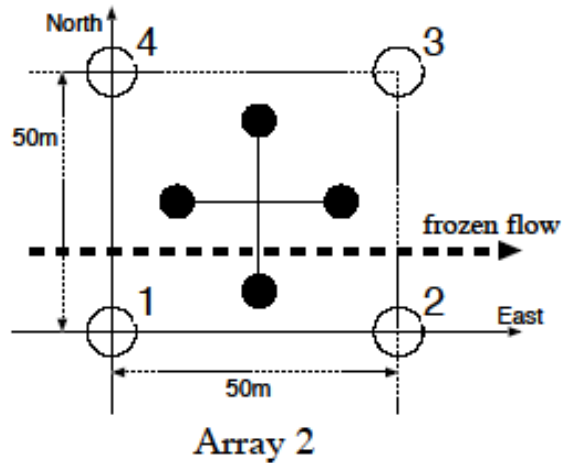
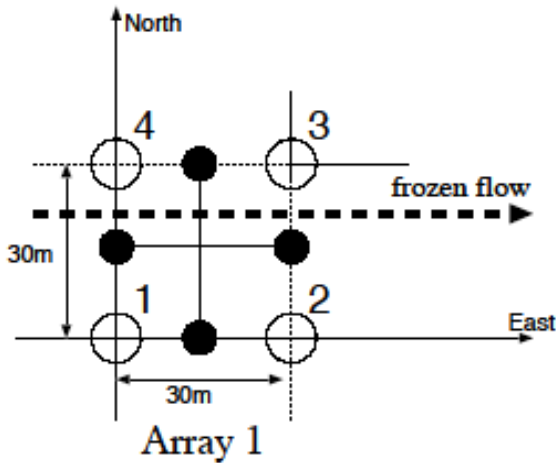
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Arrays

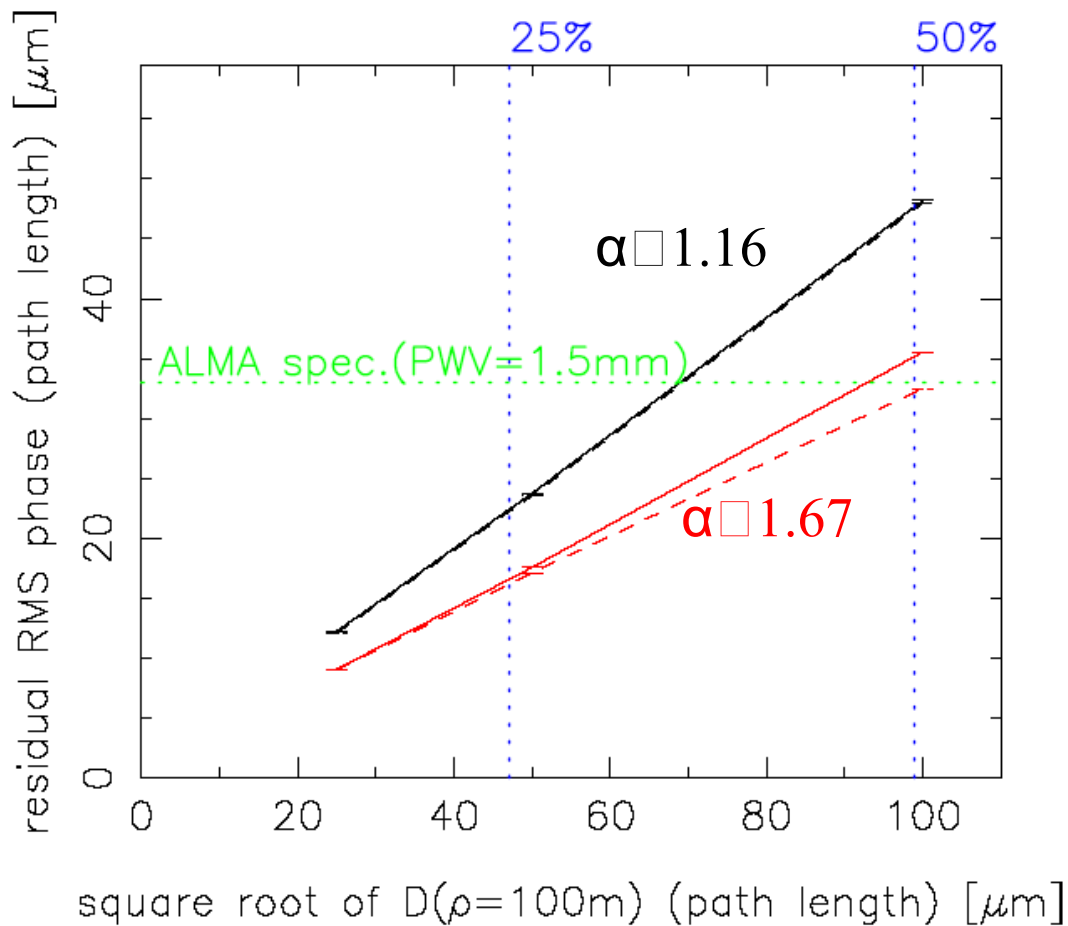
Considered in the Simulations



Results (1)

Natural Seeing

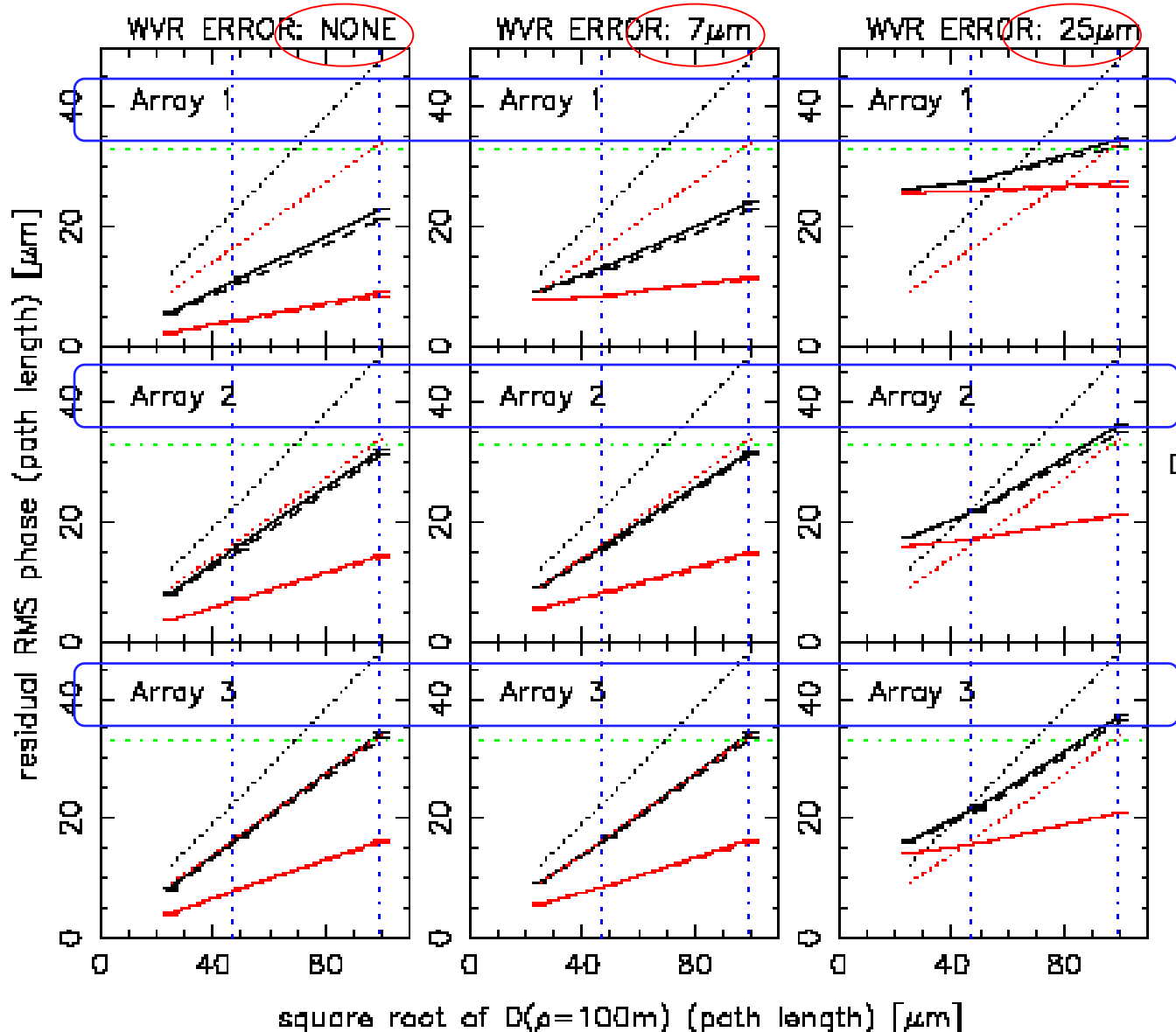
NO PHASE CALIBRATION



solid : $v=10\text{ m/s}$

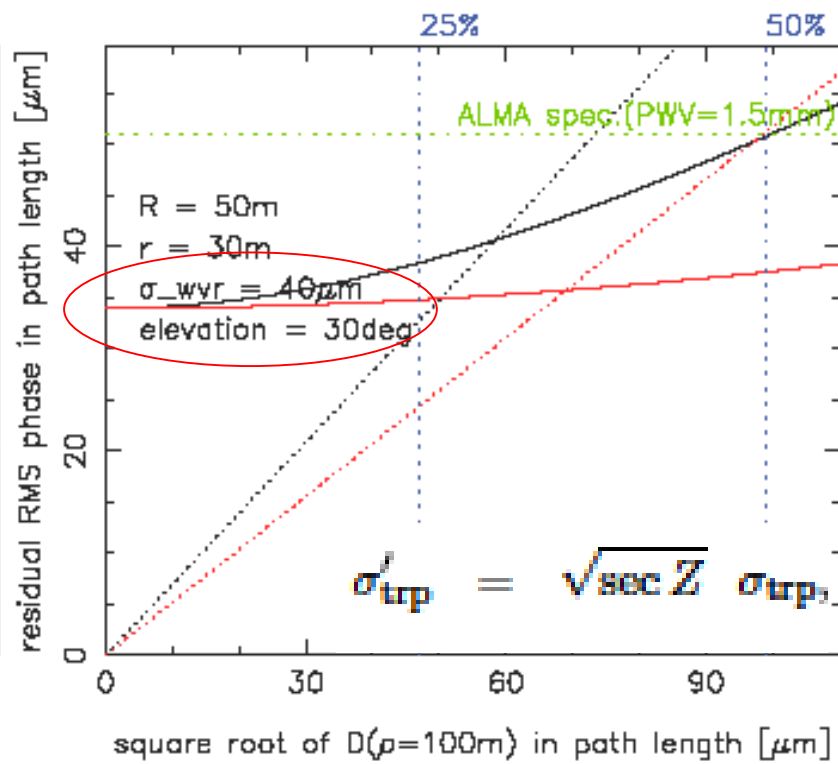
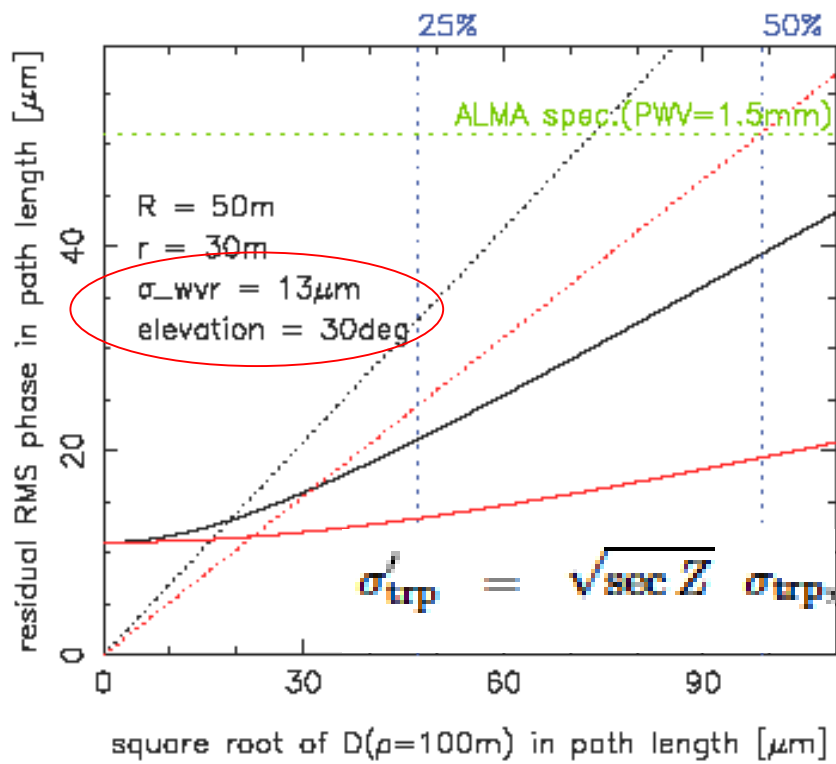
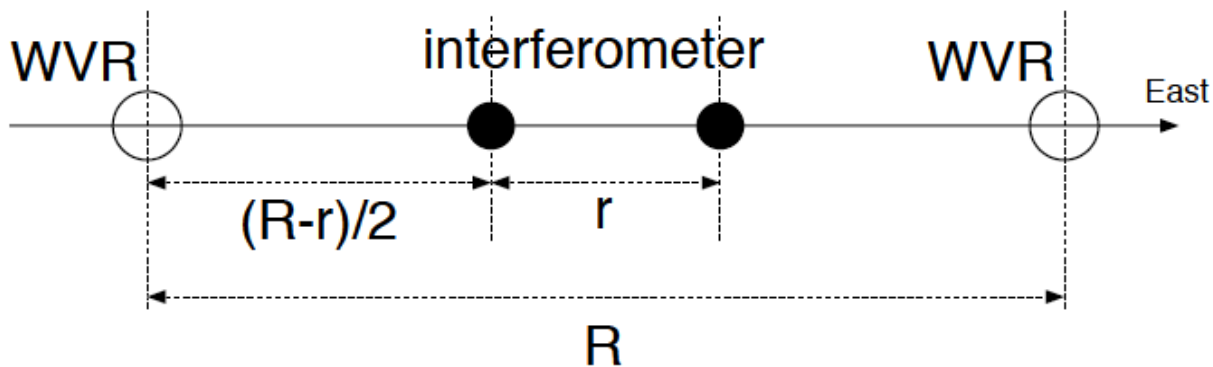
dashed : $v=5\text{ m/s}$

4-WVR 2-D SLOPE FITTING



Results (2)
WVR Phase-correction

Dotted:natural seeing
 $\square v=10\text{m/s}$





How to determine the scale factor



- Observe a phase calibrator in the interferometry mode every a few minutes simultaneously with the WVRs.
- Search the scale factor by sweeping around the *a priori* value calculated by an atmospheric model (Stirling et al, ALMA Memo #496).



Summary

- The proposed phase calibration scheme can improve the interferometer phases of the longer baselines of the ACA.
- Critical atmospheric conditions and baseline lengths for the proposed scheme are dependent on the WVR measurement errors.

ALMA Memo No. 495 (R. Hills, 2004)

Errors due to noise

